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(54) **COAXIAL CABLE INTERFACE TO
OUTDOOR BROADBAND UNIT**

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370/222, 252, 316, 328, 338, 351, 389,
370/464, 232, 254, 329, 331, 336, 337,
370/466; 705/14.4; 709/226; 725/110;
726/6

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See application file for complete search history.

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(51) **Int. Cl.**

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H01Q 1/22 (2006.01)

(57) **ABSTRACT**

An outdoor broadband unit implements full IP-based routing between a wide area network (WAN)-side interface (such as a Long-Term Evolution (LTE) air interface) and a local area network (LAN)-side interface (such as a home network using MoCA protocol). The outdoor broadband unit maintains a routing table for all connections through an internal routing system based on matching between WAN-side Internet Protocol (IP) addresses and/or ports and LAN-side IP addresses and/or ports. The outdoor broadband unit may support both connection-oriented transport layer routing (such as Transmission Control Protocol (TCP)) and connectionless transport layer routing (such as User Datagram Protocol (UDP)).

(52) **U.S. Cl.**

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(2013.01); **H01Q 1/241** (2013.01); **H01Q 1/22**
(2013.01)
USPC **370/454**; 455/3.06; 455/3.02

(58) **Field of Classification Search**

CPC H01Q 1/42; H01Q 1/246; H01Q 1/241;
H01Q 1/24; H01Q 1/22
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455/575.7, 550.1, 562.1, 575.1, 412.1, 420,
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22 Claims, 10 Drawing Sheets

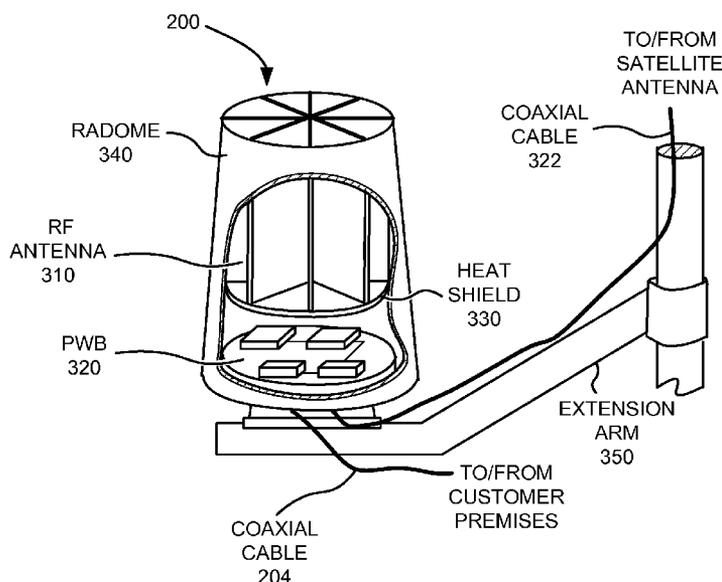
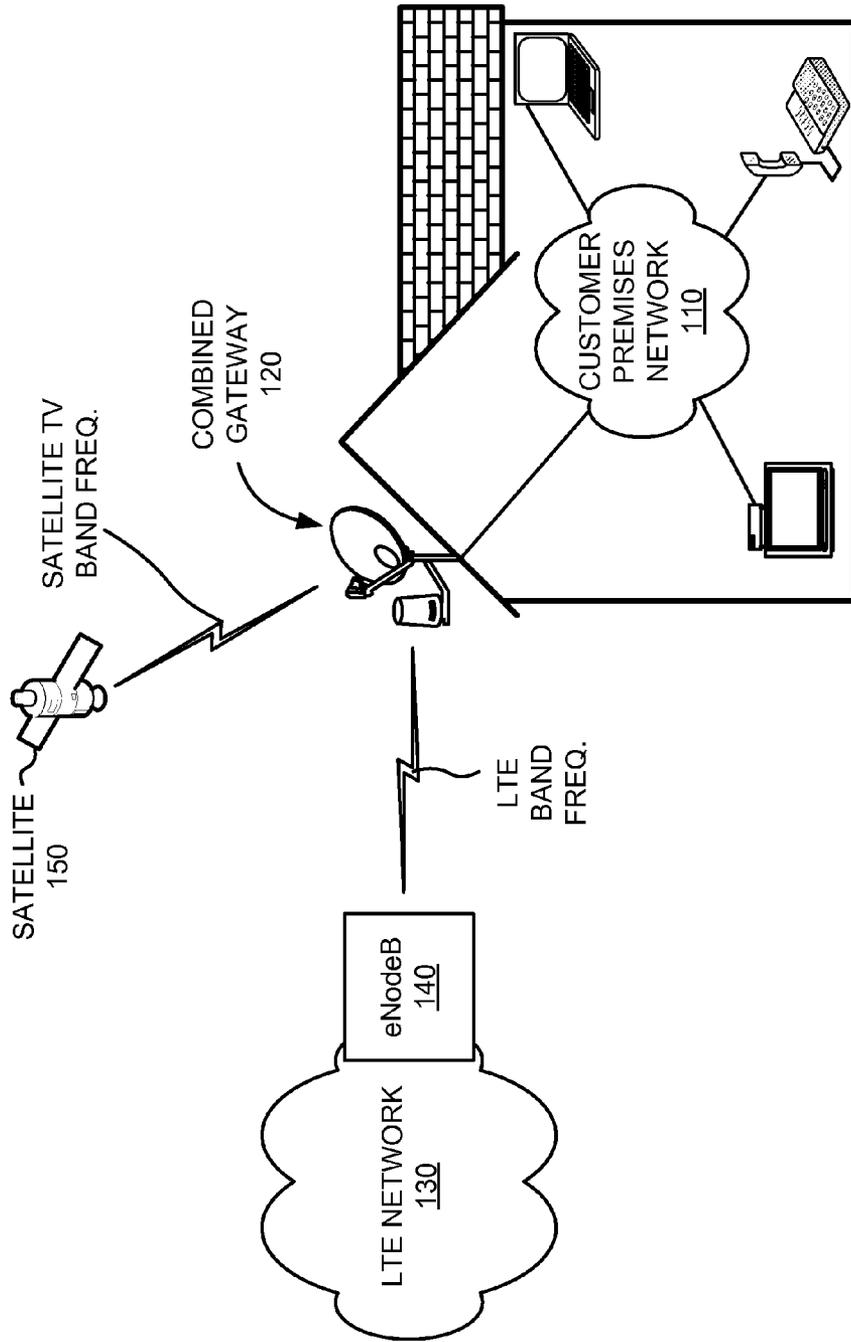


FIG. 1

100 →



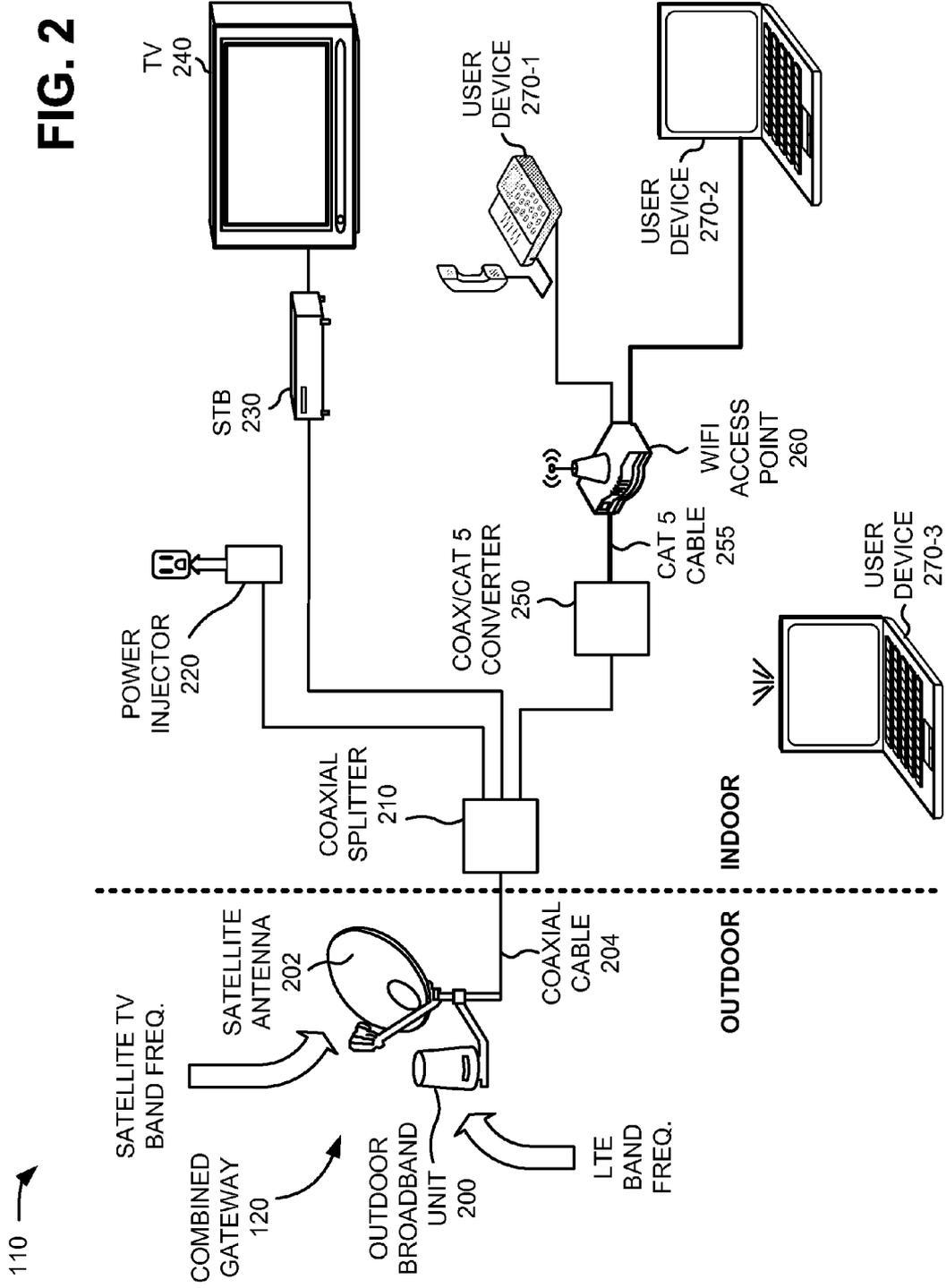
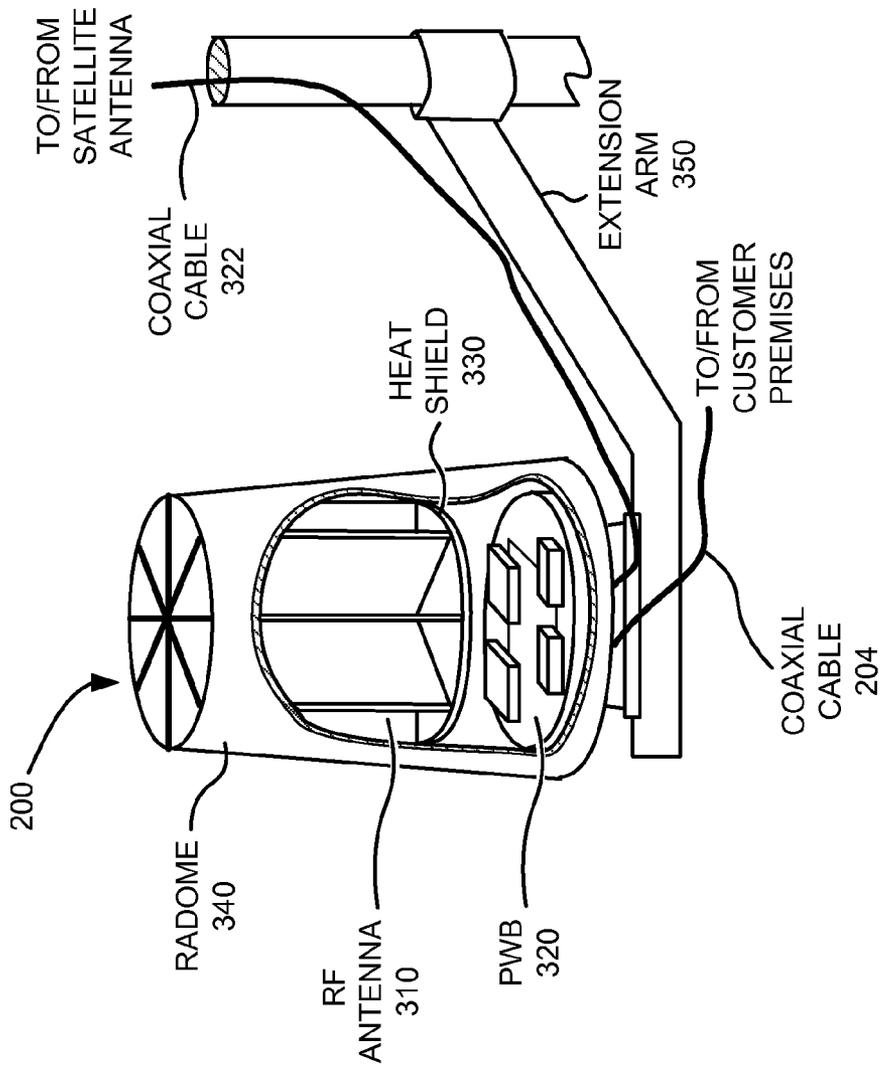


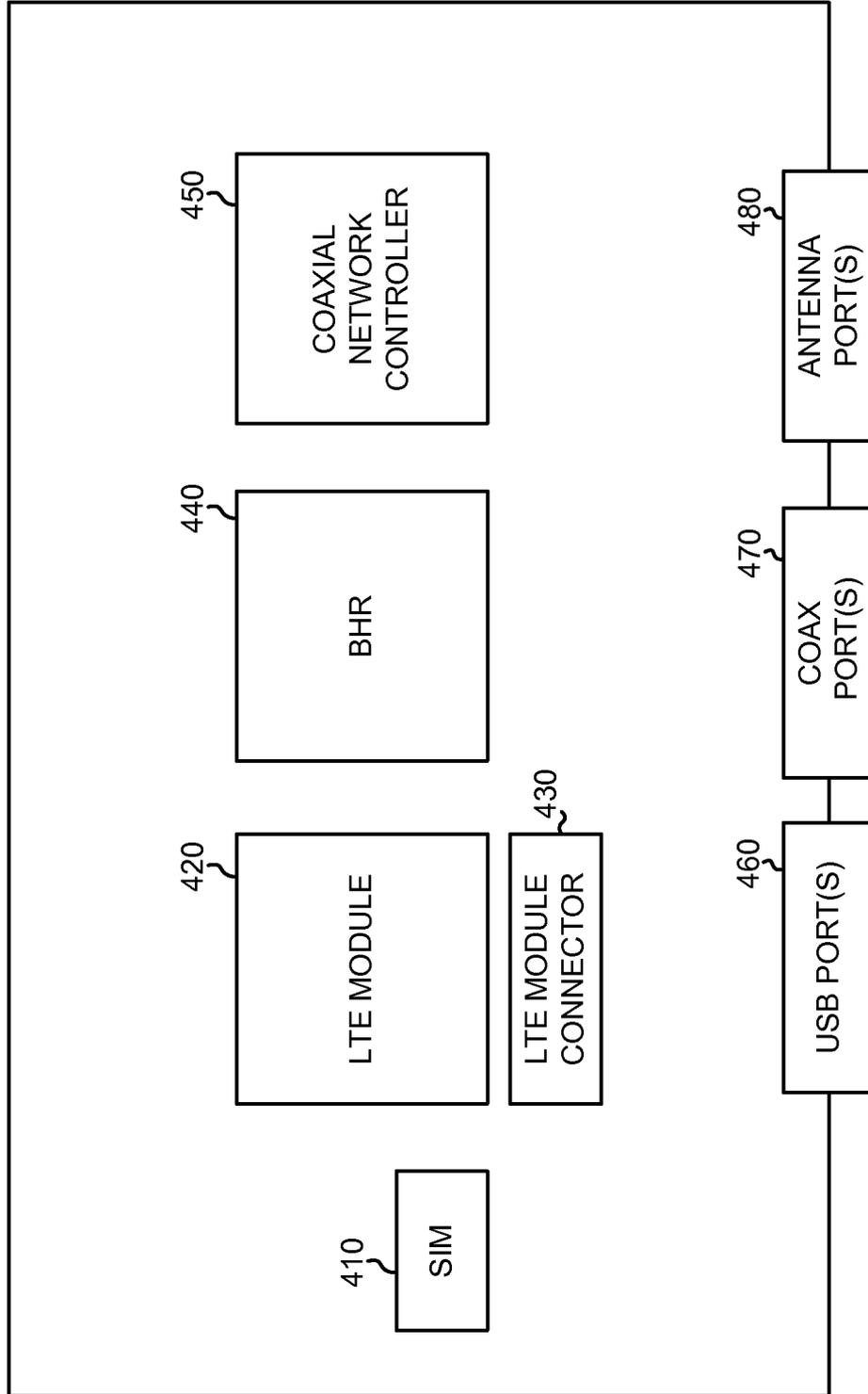
FIG. 2

110

FIG. 3



320 → **FIG. 4**



500 →

FIG. 5

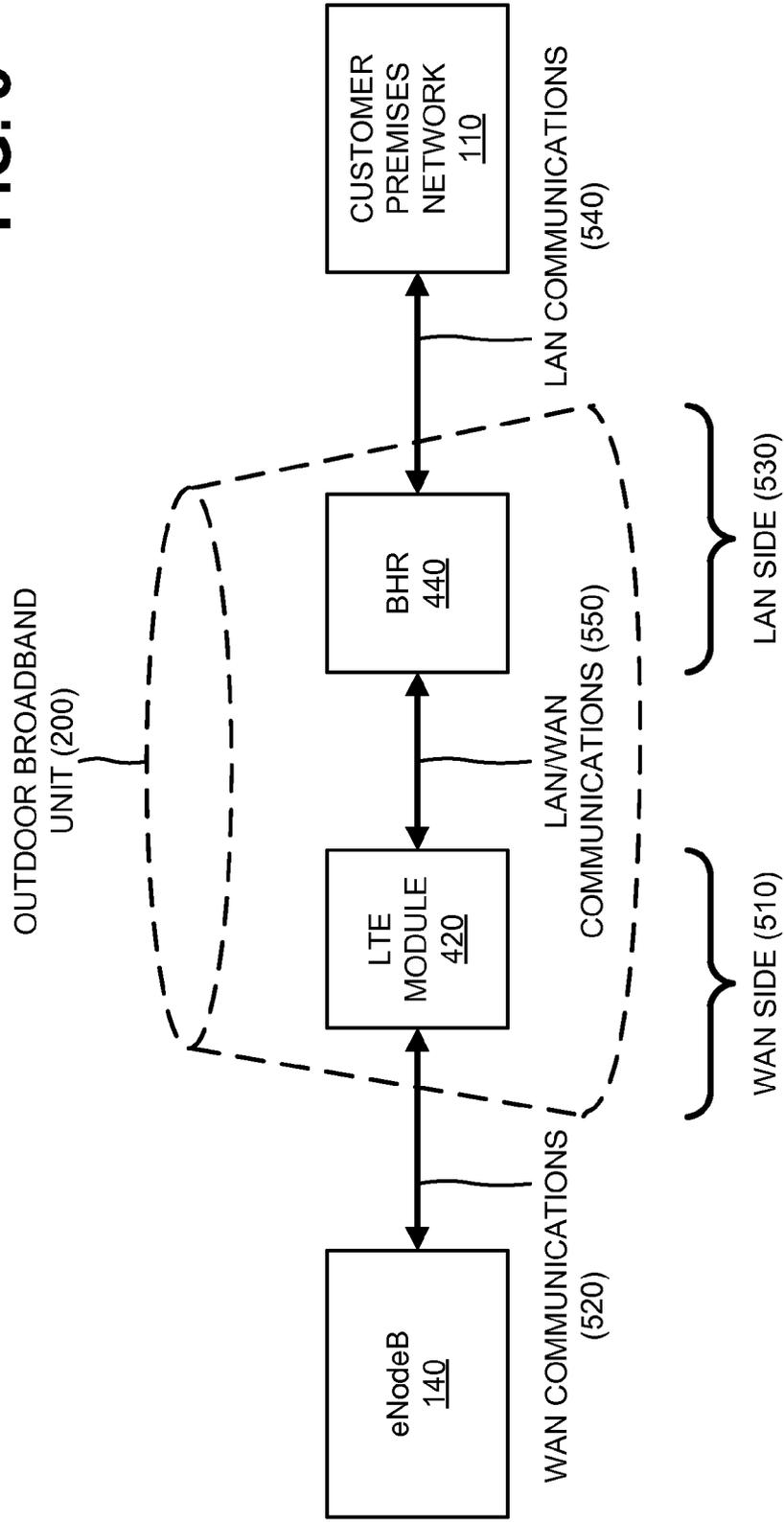


FIG. 6

420 →

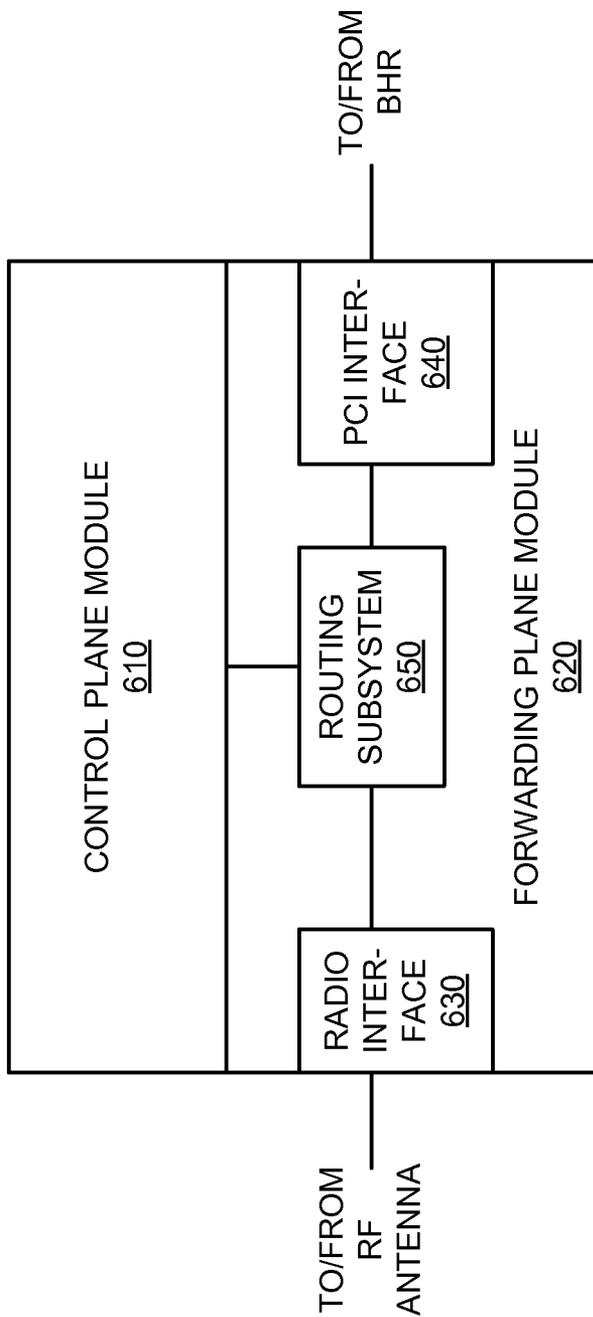
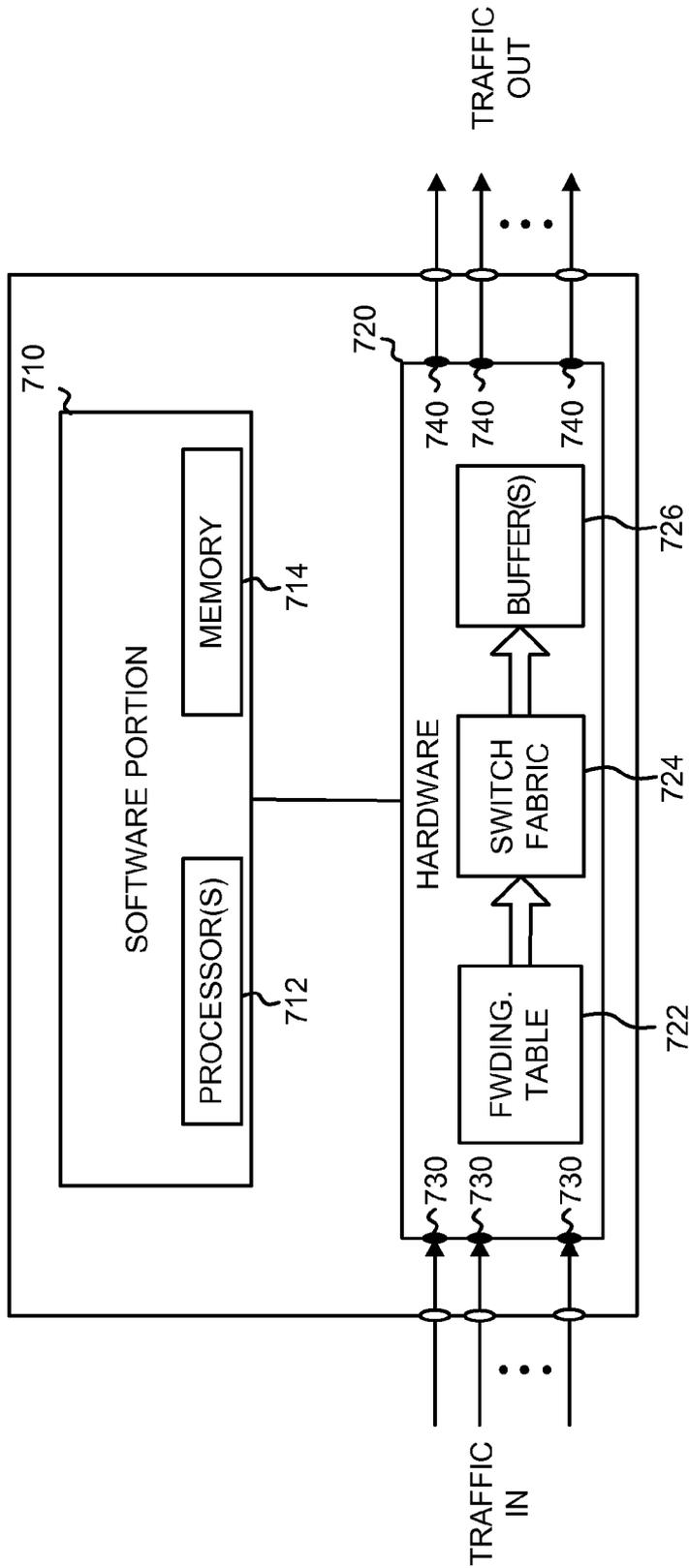


FIG. 7

440 →



800 →

FIG. 8

810 ↓	LAN DEST. IP ADDRESS	820 ↓	LAN PORT	830 ↓	WAN DEST. IP ADDRESS	840 ↓	WAN PORT
	• • •		• • •		• • •		• • •

•
•
•

FIG. 9

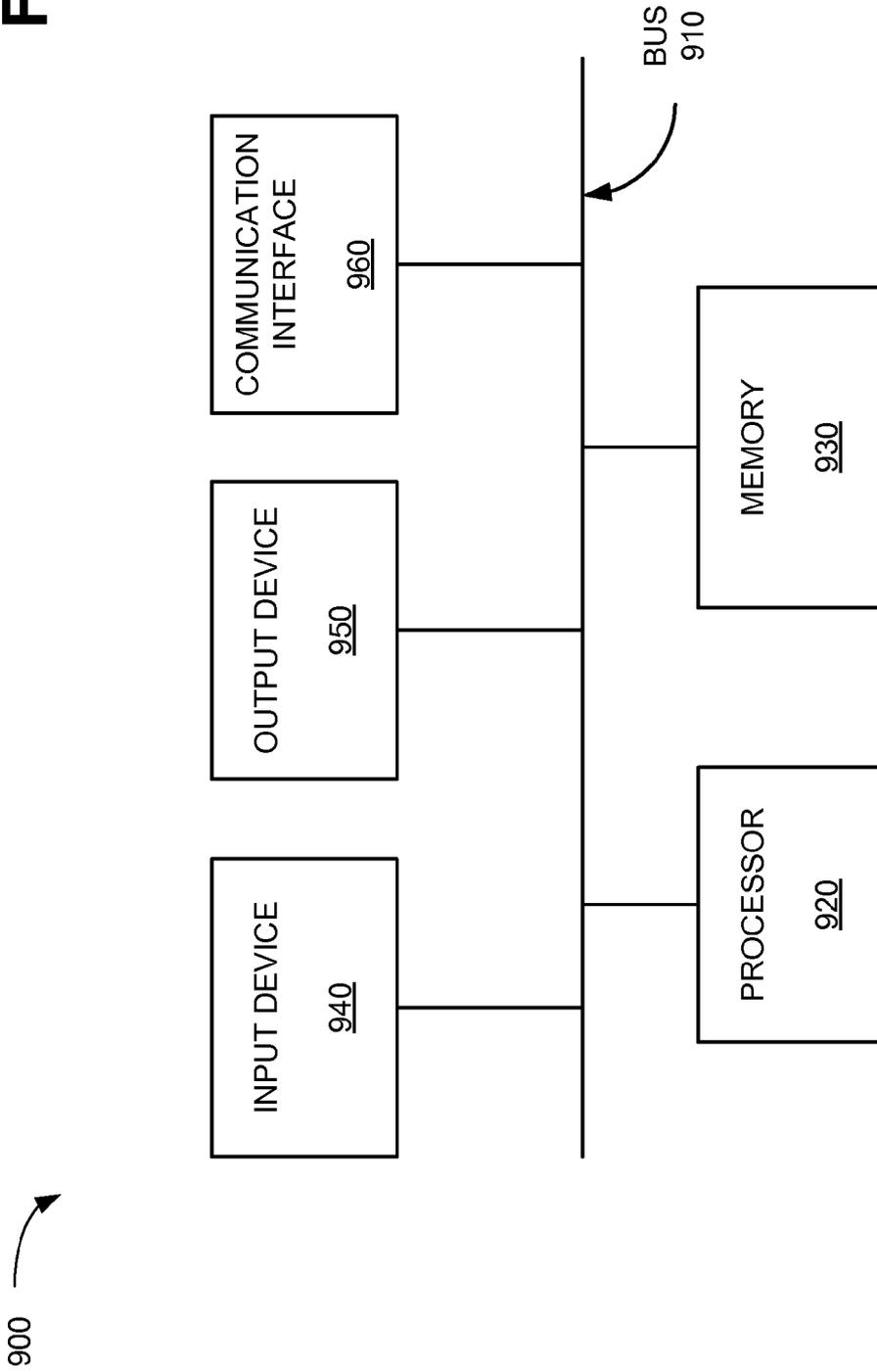
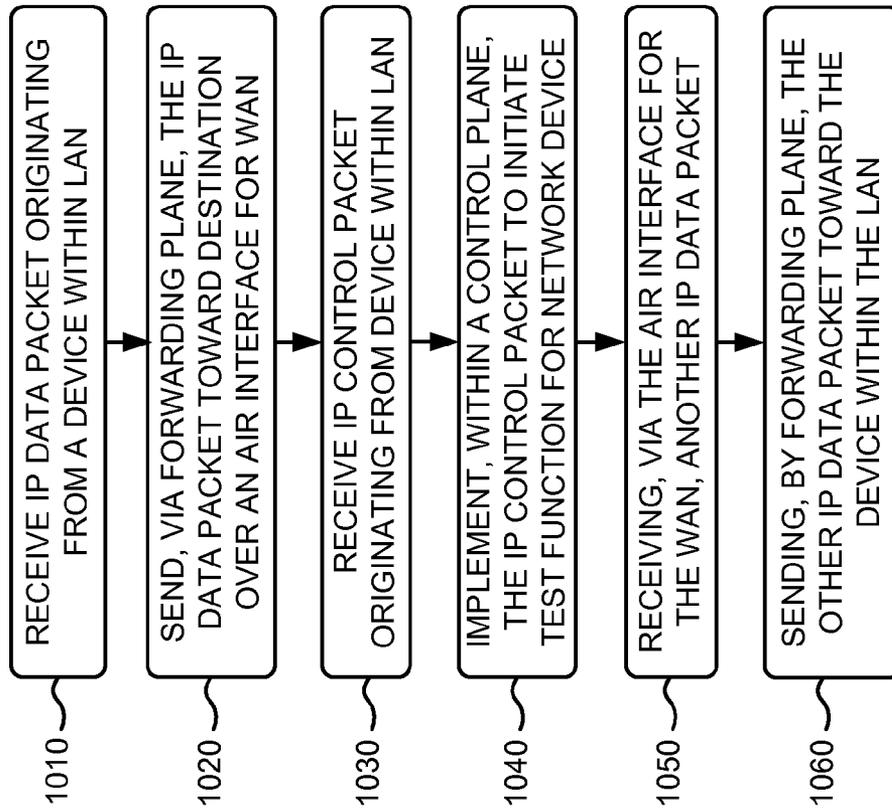


FIG. 10

1000 →



COAXIAL CABLE INTERFACE TO OUTDOOR BROADBAND UNIT

BACKGROUND INFORMATION

Bundled media services (e.g., combination packages of television, telephone, and broadband Internet services) have been successfully offered to households with wired connections to service provider networks. Households in areas without such wired connections (e.g., customer in regions that cannot be reached via conventional communication media, such as optical cables, copper cables, and/or other fixed wire-based technologies) may rely on fixed wireless services for some of these services (e.g., broadband access). Fixed wireless services can be made more attractive to customers by effectively leverage existing customer premises equipment (CPE).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram of a system according to an implementation described herein;

FIG. 2 is a diagram of a customer premises of FIG. 1 according to an implementation described herein;

FIG. 3 is a diagram of example components of an outdoor broadband unit of the customer premises network depicted in FIG. 2 according to an implementation described herein;

FIG. 4 is a diagram of example components of a printed wiring board of the outdoor broadband unit depicted in FIG. 3;

FIG. 5 is a diagram of example operations capable of being performed by an example portion of the system illustrated in FIG. 1;

FIG. 6 is a diagram of an example of a component of a Long Term Evolution (LTE) module of the PWB of FIG. 4;

FIG. 7 is a diagram of an example component of broadband home router (BHR) of the PWB of FIG. 4;

FIG. 8 is a diagram of an example portion of a routing table according to an implementation described herein;

FIG. 9 is a diagram of example components of a device that may correspond to one of the devices of the system of FIG. 1 or the customer premises network of FIG. 2; and

FIG. 10 is a flow diagram illustrating a process for routing traffic between a WAN air interface and a LAN interface according to an implementation described herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements.

Systems and/or methods described herein may include an outdoor broadband unit that implements full IP-based routing between a WAN-side interface (e.g., a Long-Term Evolution (LTE) air interface) and a LAN-side interface (e.g., a home network using standards of the Multimedia over Coax Alliance (MoCA)). The outdoor broadband unit may maintain a routing table for all connections through an internal routing system based on matching between WAN-side IP addresses and/or ports and LAN-side IP addresses and/or ports. The systems and/or methods may support both connection-oriented transport layer routing (such as Transmission Control Protocol (TCP)) and connectionless transport layer routing (such as User Datagram Protocol (UDP)).

In one implementation, the systems and/or methods may include a satellite antenna to receive communications from a

satellite network, an outdoor broadband unit connected to an external portion of a customer premises, and a support arm to hold the outdoor broadband unit and the satellite antenna. The outdoor broadband unit may include a radio frequency (RF) antenna to receive communications from a LTE network, a LTE module to implement an air interface for the LTE network, a coaxial network controller to provide an interface to a LAN, associated with the customer premises, and a broadband home router to route traffic between the WAN and the LAN. The LTE module may include a control plane module to perform control operations relating to testing of the LTE module and a forwarding plane module. The broadband home router may transfer user data, from the LAN, to both the control plane module and the forwarding plane module of the LTE module.

FIG. 1 is a diagram of a system 100 according to an implementation described herein. As shown in FIG. 1, system 100 may include customer premises network 110, gateway equipment 120, a LTE network 130, an eNodeB 140, and a satellite 150.

Customer premises network 110 may include one or more devices connected via a customer premises network. Devices in the customer premises network may include, for example, set-top boxes (STBs), televisions, computers, voice-over-Internet-protocol (VoIP) devices, home networking equipment (e.g., routers, cables, splitters, local gateways, etc.), gaming devices, etc. Devices within the customer premises network may be connected via wired connections (e.g., coaxial cable, Telecommunications Industry Association (TIA) category 5 ("Cat 5") cable, TIA Cat 3 cable, etc.) and/or wireless connections (e.g., using network devices such as those available under the IEEE 802.11 wireless local wireless network (LAN) standards). In the example shown in FIG. 1, customer premises network 110 is connected to eNodeB 140 through a two-way wireless connection (e.g., using a LTE band frequency) and connected to satellite network 150 through a one-way (e.g., downlink) wireless connection (e.g., using a satellite TV band frequency). The two-way wireless connection and the one-way wireless connection may be implemented using combined gateway equipment 120.

Combined gateway equipment 120, which is described in more detail below, may generally include mechanisms for communicating with satellite 150 (to provide satellite-based communications) and for communicating with eNodeB 140 (to provide terrestrial RF-based communications). Combined gateway equipment 120 may connect, such as via a coaxial connection, to devices inside of the customer premises, such as the devices connected to customer premises network 110.

LTE network 130 may include a core network architecture of the Third Generation Partnership Project (3GPP) LTE wireless communication standard (e.g., an evolved packet core (EPC) network). LTE network 130 may include a packet-switched core network that supports high-speed wireless and wireline broadband access technologies. Additionally, LTE network 130 may provide packet-switched voice services (e.g., which are traditionally circuit-switched) using an Internet Protocol Multimedia Subsystem Multimedia Subsystem (IMS) network (not shown in FIG. 1). LTE network 130 may include an Evolved NodeB (eNodeB) 140. In addition, LTE network 130 may include one or more other network devices (not shown), such as one or more mobility management entities (MMES), serving gateways (SGWs), packet data network (PDN) gateways (PGW), and/or other devices.

eNodeB 140 may include a LTE base station that may cover a particular geographic area serviced by LTE network 130. eNodeB 140 may include one or more devices that receive information, such as voice, video, text, and/or other data,

from network devices and/or that transmit the information to customer premises **110** via an air interface. eNodeB **140** may also include one or more devices that receive information from devices in customer premises **110** via an air interface and/or that transmit the information to other network devices.

Satellite **150** may provide multimedia content from, for example, a direct broadcast satellite (DBS) service provider (not shown in FIG. 1). Satellite **150** may provide a downlink signal over a designated satellite TV band frequency (e.g., in the range of 950 megahertz (MHz) to 2150 MHz). The downlink signal may be received using a satellite antenna/receiver system at customer premises **110** to present satellite TV content to a user.

In implementations described herein, customer premises network **110** may combine LTE functionality with satellite TV service. Using combined gateway equipment **120**, both broadband (over LTE) service (e.g., via eNodeB **140**) and satellite TV service (e.g., via satellite **150**) may be brought into customer premises network **110** over a single coaxial line. This architecture may reduce equipment installation time due to the use of a single coaxial line for all the services. Both installation costs and recurrent operational costs can be reduced.

While implementations herein are described primarily in the context of broadband services via LTE, other wireless protocols may be used. For example, components conforming to LTE standards described herein may be replaced by components conforming to other network protocols (e.g., Global System for Mobile Communications (GSM), wide-band code division multiple access (WCDMA), Ultra Mobile Broadband (UMB), Universal Mobile Telecommunications System (UMTS), Code Division Multiple Access 2000 (CDMA2000), High-Speed Packet Access (HSPA), Worldwide Interoperability for Microwave Access (WiMax), etc.).

Although FIG. 1 shows example components of system **100**, in other implementations, system **100** may include fewer components, different components, differently arranged components, and/or additional components than those depicted in FIG. 1. Alternatively, or additionally, one or more components of system **100** may perform one or more tasks described as being performed by one or more other components of system **100**.

FIG. 2 is a diagram of customer premises network **110** according to an implementation described herein. As illustrated, combined gateway equipment **120** of customer premises network **110** may include an outdoor broadband unit **200** and a satellite antenna **202**. A coaxial cable **204** may connect combined gateway equipment **120** to the indoor portion of customer premises network **110**. Customer premises network **110** may further include a coaxial splitter **210**, a power injector **220**, a set-top box (STB) **230**, a television **240**, a coax/Cat 5 converter **250**, a local router **260**, and user devices **270-1**, **270-2**, and **270-3** (referred to herein collectively as “user devices **270**” or individually as “user device **270**”). One outdoor broadband unit **200**, one coaxial splitter **210**, one power injector **220**, one STB **230**, one television **240**, one coax/Cat 5 converter **250**, one local router **260**, and three user devices **270** have been illustrated in FIG. 2 for simplicity. In practice, there may be more (or fewer) outdoor broadband units **200**, satellite antennas **202**, coaxial splitters **210**, power injectors **220**, STBs **230**, televisions **240**, coax/Cat 5 converters **250**, WiFi access points **260**, and/or user devices **270**.

Outdoor broadband unit **200** may include one or more data processing and/or data transfer devices, such as a gateway, a router, a modem, a switch, a firewall, a network interface card, a hub, a bridge, a proxy server, an optical add-drop multi-

plexer (OADM), and/or some other type of device that processes and/or transfers data. In one example, outdoor broadband unit **200** may include a wireless gateway that provides a convergence point between wireless protocols (e.g., associated with eNodeB **140**) and IP protocols (e.g., associated with user devices **270**). Outdoor broadband unit **200** may be physically deployed with satellite antenna **202** (e.g., on a roof or a side wall of a house associated with customer premises network **110**) as part of combined gateway equipment **120**. For example, outdoor broadband unit **200** may utilize a pre-existing or new satellite TV installation in a way that both broadband (over LTE) service and satellite TV are brought indoors (e.g., inside the customer premises) over, for example, a coaxial cable **204**. Components of outdoor broadband unit **200** may also be powered using coaxial cable **204**.

Satellite antenna **202** may provide an interface for television service broadcast from satellites. In one implementation, satellite antenna **202** may provide an entry point for a network (e.g., customer premises network **110**) that conforms to standards of the Multimedia over Coax Alliance (MoCA). Generally, MoCA-compliant devices may be used to implement a home network on existing coaxial cable, using, for example, orthogonal frequency-division multiplexing (OFDM) modulation that divides data into several parallel data streams or logical channels. Channel stacking technology, such as the Single Wire Multiswitch (SWiM) technology, may be used to allocate logical channels using frequency blocks for user-selected programming to the SWiM compatible devices (e.g., STBs **230**). Satellite antenna **202** may communicate with STB **230** to identify which blocks of channels can be used to send television signals to that particular STB **230**.

Coaxial splitter **210** may include splitting technologies to filter LTE and satellite TV signals. In one implementation, coaxial splitter **210** may include a SWiM splitter. For example, coaxial splitter **210** may facilitate allocating logical channels using different frequency blocks for viewer-selected television programming and broadband signals to SWiM-compatible STB **230** and/or Local router **260**.

Power injector **220** may include a mechanism for injecting DC power in a coaxial cable to power remotely-located devices, such as outdoor broadband unit **200**. Use of power injector **220** may allow components of outdoor broadband unit **200** to be powered via a coaxial cable (e.g., coaxial cable **204**) and eliminate the need for additional wiring. In one implementation, power injector **220** may include an on-off switch (or button).

STB **230** may include a device that receives and/or processes video content (e.g., from a satellite TV provider via satellite antenna **202**), and provides the video content to television **240** or another device. STB **230** may also include decoding and/or decryption capabilities and may further include a digital video recorder (DVR) (e.g., a hard drive). In one implementation, STB **230** may conform to MoCA and SWiM standards.

Television **240** may include a television monitor that is capable of displaying video content, television programming, content provided by STB **230**, and/or content provided by other devices (e.g., a digital video disk (DVD) player, a video camera, etc., not shown) connected to television **240**. Coax-to-Cat 5 adapter **250** may include a device to convert incoming signals from coaxial cables to outgoing signals on Cat 5 cables, such as cat 5 cable **255**.

Local router **260** may include a device that may provide connectivity between equipment within customer premises (e.g., user devices **270**) and between the customer premises equipment and an external network (e.g., network **130**). In one implementation, local router **260** may include a wireless

access point that employs one or more short-range wireless communication protocols for a wireless personal area network (WPAN) and/or a wireless local area network (WLAN), such as, for example, IEEE 802.15 (e.g., Bluetooth) and IEEE 802.11 (e.g., Wi-Fi). In other implementations, different short-range wireless protocols and/or frequencies may be used. Local router 260 may also include one or more wired (e.g., Ethernet) connections. In one implementation, local router 260 may include a USB Ethernet Router that is capable of meeting LTE quality of service (QoS) standards.

User devices 270 may include any device that is capable of communicating with customer premises network 110 via local router 260. For example, user device 270 may include a mobile computation and/or communication device, such as a laptop computer, a VoIP-enabled device, a radiotelephone, a personal communications system (PCS) terminal (e.g., that may combine a cellular radiotelephone with data processing and data communications capabilities), a personal digital assistant (PDA) (e.g., that can include a radiotelephone, a pager, Internet/intranet access, etc.), a wireless device, a smart phone, a global positioning system (GPS) device, a content recording device (e.g., a camera, a video camera, etc.), etc. In another example, user device 270 may include a fixed (e.g., provided in a particular location, such as within a customer's home) computation and/or communication device, such as a VoIP-enabled device phone base, a personal computer, a gaming system, etc.

Although FIG. 2 shows example components of customer premises network 110, in other implementations, customer premises network 110 may include fewer components, different components, differently arranged components, and/or additional components than those depicted in FIG. 2. Alternatively, or additionally, one or more components of customer premises network 110 may perform one or more tasks described as being performed by one or more other components of customer premises network 110.

FIG. 3 is a diagram of example components of outdoor broadband unit 200. As shown in FIG. 3, outdoor broadband unit 200 may include a radio frequency (RF) antenna 310, a printed wiring board (PWB) 320, a heat shield 330, and a radome 340. Outdoor broadband unit 200 may be mounted on an extension arm 350 connected to a pole supporting satellite antenna 202 (not shown).

RF antenna 310 may include an antenna to transmit and/or receive RF signals over the air. RF antenna 310 may, for example, receive RF signals from components on PWB 320 and transmit the RF signals over the air. Also, RF antenna 310 may, for example, receive RF signals over the air and provide the RF signals to components on PWB 320. In one implementation, for example, the components on PWB 320 may communicate with a base station (e.g., eNodeB 140) connected to a network (e.g., LTE network 130) to send and/or receive signals from user devices 270. In one implementation, RF antenna 310 may include a wideband multiple beam antenna, with partially overlapping antenna beams, spanning 360 degrees in azimuth (x-y plane). For example, RF antenna 310 may include between four and eight beams (e.g., to achieve desirable antenna gains and reduction of interference). Additionally, or alternatively, RF antenna 310 may employ two polarizations per beam for 2x2 downlink multiple-input and multiple-output (MIMO) operation.

PWB 320 may include a substrate that mechanically holds and connects various electronic components that are installed onto PWB 320. PWB 320 may include, for example, a laminate structure that routes signals between electronic components that are mounted on PWB 320. Although described as a printed wiring board, PWB 320 could equivalently be

referred to as a printed circuit board (PCB), an etched wiring board, or a printed circuit assembly (PCA). PWB 320 may, for example, include components to receive broadband signals via RF antenna 310 and satellite signals from satellite antenna 202 (not shown) via coaxial cable 322 and to combine the broadband and satellite signals to customer premises via coaxial cable 204. Additionally, PWB 320 may receive signals from customer premises via coaxial cable 204 to transmit to via RF antenna 310 to LTE network 130/eNodeB 140.

Heat shield 330 may define a barrier between antenna 310 and PWB 320. Heat shield 330 may include, for example, a heat insulating material. In some implementations, heat shield 330 may also act as a RF shield to shield stray RF signals, produced by components on PWB 320, from antenna 310.

Radome 340 (shown with cut-away view to reveal RF antenna 310, PWB 320, and heat shield 330) may provide a weatherproof enclosure to protect RF antenna 310, PWB 320, and heat shield 330, and/or other components of outdoor broadband unit 200. Radome 340 may include any RF transparent structure that protects components in an outdoor environment. In implementations herein, radome 340 may enclose RF antenna 310, may be integrated with RF antenna 310, or may support external mounting of RF antenna 310.

Although FIG. 3 shows example components of outdoor broadband unit 200, in other implementations, outdoor broadband unit 200 may include fewer components, different components, differently arranged components, and/or additional components than depicted in FIG. 3. Alternatively, or additionally, one or more components of outdoor broadband unit 200 may perform one or more tasks described as being performed by one or more components of outdoor broadband unit 200.

FIG. 4 is a diagram of example components that may be installed on PWB 320. PWB 320 may include a subscriber identity module (SIM) 410, a LTE module 420, a LTE module connector 430, a broadband home router (BHR) 440, and a coaxial network controller 450. PWB 320 may also include a number of connectors to connect to external devices or systems, such as customer premises network 110, RF antenna 310, and/or satellite antenna 202. The connectors shown in FIG. 4 may include: universal serial bus (USB) port(s) 460, coaxial port(s) 470, and antenna port(s) 480. The components shown in FIG. 4 may be implemented as integrated circuits or other electronic components and illustrate various functionality that may be included on PWB 320. For simplicity, conductive traces connecting the components shown in FIG. 4 are not illustrated.

SIM 410 may include a SIM card or integrated circuit (chip). In general, SIM 410 may function to identify and provide services, such as security services, to the subscriber, associated with the customer premises, when connecting to the LTE network through eNodeB 140. SIM 410 may contain, for example, a unique serial number (such as an integrated circuit card identifier (ICCID)), an internationally unique number associated with customer premises network 110, security authentication and ciphering information, and/or a list of the services to which customer premises network 110 has access.

LTE module 420 may include hardware or a combination of hardware and software having communication capability via an air interface. In other words, LTE module 420 may be a control module for the LTE air interface. For example, LTE module 420 may receive broadband signals and/or voice over Internet protocol (VoIP) signals from eNodeB 140 (e.g., via antenna 410) and transmit broadband signals and/or VoIP

signals to eNodeB **140** (e.g., via antenna **410**). LTE module **420** may employ frequency division duplex (FDD) and/or time division duplex (TDD) techniques to facilitate downlink and uplink transmissions. In one implementation, LTE module **420** may include a beam selection mechanism that selects the best antenna beam, from RF antenna **410**, according to a certain optimization criteria. Beam selection may be performed, for example, during initial installation and/or regular maintenance of outdoor broadband unit **200**. Additionally, or alternatively, LTE module **420** may select any of the antenna beams, based on real-time measurements, during normal operation. LTE module **420** may connect to antenna **410** through antenna port(s) **490**. In one implementation, LTE module **420** may be manufactured as an insertable card, such as a mini-PCI (peripheral component interconnect) card that may be inserted into PWB **320**. LTE module connector **430** may include a slot, such as a PCI slot, into which LTE module **420** may be inserted and connected to PWB **320**.

In one implementation, LTE module **420** may receive IP data packets originating from a device within a LAN, such as customer premises network **110** and may send the IP data packets toward a destination via an air interface for a WAN, such as network **130**. LTE module **420** may also receive, via the air interface for the WAN, other IP data packets, and may send the other IP data packets toward the device within the LAN. LTE module **420** may further receive IP control packets originating from the device within the LAN and implement the IP control packets to initiate a test function or maintenance function for the network device. Additionally, or alternatively, LTE module **420** may receive software updates and other control plane information via the air interface for the WAN.

LTE module connector **430** may include a slot, such as a PCI slot, into which LTE module **420** may be inserted and connected to PWB **320**.

BHR **440** may include a device for buffering and forwarding data packets toward destinations. BHR **440** may, for instance, receive data packets from eNodeB **140** (e.g., via LTE module **420**) and forward the data packets toward user devices **270**. In addition, BHR **440** may receive data packets from user devices **270** (e.g., via local router **260**) and forward the data packets toward recipient devices via LTE network **130**.

In one implementation, BHR **440** may include a memory to buffer Ethernet traffic between coaxial network controller **450** and LTE module **420**. Generally, data rates from the MoCA interface with customer premises network **110** can exceed outgoing data rates over LTE module. Thus, BHR **440** may buffer packets to prevent dropped packets for outbound traffic through outdoor broadband unit **200**. BHR **440** may also buffer packets for inbound traffic through outdoor broadband unit **200**.

Coaxial network controller **450** may provide an interface for Ethernet over coaxial signals, such as signals transmitted over coaxial cable **204** and into customer premises network **110**. Coaxial network controller **450** may act as a bridge device to receive signals from LTE module **420** and to convert the signals to an Ethernet over coax signal. The Ethernet over coax signal may be assigned a logical channel (e.g., according to SWiM guidelines) and may be combined with coaxial input from satellite antenna **202**. In one implementation, the output from coaxial network controller **450** may be inserted in a Mid-RF MoCA channel that is separate from the 950 MHz to 2150 MHz range of a typical satellite TV system.

PWB **320** may additionally include a number of output ports or physical interfaces. USB port(s) **460** may include ports for connecting to external devices through the USB

serial communication standard. USB port(s) **460** may, for example, be used for diagnostic purposes, such as a port through which a technician can connect to PWB **410**.

Coaxial port(s) **470** may include an interface for coaxial cables. As previously described, in one implementation, outdoor broadband unit **200** may be connected to a coaxial cable leading to satellite antenna **202** and a coaxial cable (e.g., coaxial cable **204**) leading to customer premises network **110**. Coaxial network controller **450** may provide a logical interface for coaxial port(s) **470**. Antenna port(s) **480** may provide a physical connection to one or more antennas, such as antenna **310**. In one implementation, antenna port(s) **480** may include a first connection to a RX (receiving) antenna and a second connection to a RX/TX (receiving/transmitting) antenna.

Although FIG. **4** shows example components of PWB **320**, in other implementations, PWB **320** may contain fewer components, different components, differently arranged components, and/or additional components than depicted in FIG. **4**. Alternatively, or additionally, one or more components of PWB **320** may perform one or more other tasks described as being performed by one or more other components of PWB **320**.

FIG. **5** is a diagram of example operations capable of being performed by an example portion **500** of environment **100**. As shown in FIG. **5**, environment portion **500** may include customer premises network **110**, eNodeB **140**, outdoor broadband unit **200**, LTE module **420**, and BHR **440**. Customer premises network **110**, eNodeB **140**, outdoor broadband unit **200**, LTE module **420**, and BHR **440** may include the features described above in connection with one or more of, for example, FIGS. **1-4**.

As further shown in FIG. **5**, LTE module **420** may make up a WAN side **510** of outdoor broadband unit **200** since LTE module **420** may be associated with a WAN provided via eNodeB **140** and/or network **130** (not shown). In one example implementation, LTE module **420** may be referred to as a “WAN side network device” or a “WAN side component” of outdoor broadband unit **200**. eNodeB **140** and LTE module **420** may exchange WAN communications **520**. WAN communications **520** may include wireless protocol-based communications associated with the broadband (over LTE) service information exchanged between eNodeB **140** and outdoor broadband unit **200**. In one example implementation, WAN communications **520** may include authentication communications (e.g., username and password configurations), provisioning communications associated with outdoor broadband unit **200**, etc.

BHR **440** may make up a LAN side **530** of outdoor broadband unit **200** since BHR **440** may be associated with a LAN provided via customer premises network **110**. In one example implementation, BHR **440** may be referred to as a “LAN side network device” or a “LAN side component” of outdoor broadband unit **200**. Customer premises network **110** and BHR **440** may exchange LAN communications **540**. LAN communications **540** may include IP protocol-based communications associated with information exchanged between customer premises network **110** (e.g., user devices **270**) and outdoor broadband unit **200**. In one example implementation, LAN communications **540** may include requests for video content, requests for audio content, etc.

As further shown in FIG. **5**, LTE module **420** and BHR **440** may exchange LAN/WAN communications **550**. LAN/WAN communications **550** may include communications that enable outdoor broadband unit **200** to provide a convergence point between wireless protocols (e.g., associated with eNo-

deB 140) and IP protocols (e.g., associated with user devices 270 of customer premises network 110).

Although FIG. 5 shows example components of environment portion 500, in other implementations, environment portion 500 may include fewer components, different components, differently arranged components, or additional components than depicted in FIG. 5. Alternatively, or additionally, one or more components of environment portion 500 may perform one or more other tasks described as being performed by one or more other components of environment portion 500.

FIG. 6 is a diagram of example functional components of LTE module 420. As shown in FIG. 6, LTE module 420 may include a control plane module 610 and a forwarding plane module 620. Forwarding plane module 620 may include a radio interface 630 and a PCI interface 640 interconnected by a routing sub-system 650. In one implementation, control plane module 610 and user plane module 620 may be included in separate chips on LTE module 420.

Control plane module 610 may perform control operations relating to testing and/or maintenance of LTE module 420 and/or connectivity to LTE network 130. In one implementation, control plane module 610 may receive a command to specify a test mode for testing LTE module 420. In one implementation, control plane module 610 may be configured to receive communications from a test device (e.g., a portable computing device used by a technician) via a separate physical connection, such as a RJ-45 connection to a control plane interface (not shown). In implementations described herein, control plane module 610 may also be configured to receive IP control packets (e.g., to implement test functions) from devices 270 within customer premises network 110 via a MoCA interface. Thus, test functions of control plane module 610 may be accessed and/or implemented without using a separate physical connection to outdoor broadband unit 200.

Forwarding plane module 620 may receive and process user data, such as broadband traffic, for distribution to/from devices (e.g., user devices 270) in customer premises network 110. For example, forwarding plane module 620 may receive data from LTE network 130 via radio interface 630 and may forward the data toward user devices 270 in customer premises network 110 via PCI interface 640. Forwarding plane module 620 (or components within forwarding plane module 620) may be associated with one or more LAN side 530 IP addresses/ports.

Radio interface 630 may provide an air interface with eNodeB 140 to enable WAN communications (e.g., WAN communications 520) with LTE network 130. PCI interface 640 may provide an electrical connection to BHR 440 to enable LAN communications (e.g., LAN communications 540) with customer premises network 110 over a MoCA interface.

Routing subsystem 650 may receive traffic from radio interface 630 and may route the traffic to toward devices in customer premises network 110 (via PCI interface 640) and/or control plane module 610. Additionally, routing subsystem may receive traffic from customer premises network 110 (via PCI interface 640) and rout traffic toward LTE network 130 and/or control plane module 610. For example, routing subsystem 650 may receive, from BHR 440, traffic with an IP address for control plane module 610 and may forward that traffic to control plane module 610 based on the IP address. Thus, LTE module 420 (and broadband home router 200, generally) may support both connection-oriented transport layer routing (such as TCP) and connectionless transport layer routing (such as UDP).

Conventionally, to perform certain maintenance and/or test operations, a test mode command is entered by connecting a test device (e.g., a laptop computer) to a separate interface for control plane module 610. For example, a technician may connect a test device to control plane module 610 via a RJ-45 interface and an Ethernet cable. The technician may then provide appropriate passwords and/or selections to input a test mode command and implement test mode functionality. However, the physical location (e.g., on a roof or side of a building) of outdoor broadband unit 200 may preclude physical attachment to a separate control plane interface.

In implementations described herein, LTE module 420 may include routing subsystem 650 to receive both forwarding plane data and control plane signals via PCI interface 640. Particularly, LTE module 420 may support full IP-based routing between control plane module 610 and forwarding plane module 620. Thus, a test device (e.g., user device 270 or another device) may connect to customer premises network 110 to send control signals (e.g., a test mode command entered by a technician) to control plane module 610 using LAN communications (e.g., LAN communications 540).

Although FIG. 6 shows example functional components of LTE module 420, in other implementations, LTE module 420 may include fewer functional components, different functional components, differently arranged functional components, or additional functional components than depicted in FIG. 6. Alternatively, or additionally, one or more functional components of LTE module 420 may perform one or more other tasks described as being performed by one or more other functional components of LTE module 420.

FIG. 7 is a diagram of example components of BHR 440. As shown in FIG. 7, BHR 440 may include a software portion 710 and a hardware portion 720. Software portion 710 may include software designed to control BHR 440. Software portion 710 may, for example, implement an operating system for BHR 440 and may execute processes designed to implement the network protocols used by BHR 440. Software portion 710 may control hardware portion 720 and provide an interface for user configuration of BHR 440.

Software portion 710, although shown as a single abstract block 710 in FIG. 7, may be implemented through, for example, one or more general purpose processor(s) 712 and one or more computer memories 714. Processor(s) 712 may include processors, microprocessors, or other types of processing logic that may interpret and execute instructions. Computer memory 714 (also referred to as computer-readable media herein) may include random access memory (RAM), read-only memory (ROM), or another type of storage device that may store information and instructions for execution by processor(s) 712.

As described herein, BHR 440 may perform certain operations in response to processor(s) 712 executing software instructions contained in a computer-readable medium, such as memory 714. A computer-readable medium may be defined as a non-transitory memory device. A memory device may include memory space within a single physical memory device or spread across multiple physical memory devices. The software instructions may be read into memory 714 from another computer-readable medium or from another device. The software instructions contained in memory 714 may cause processor(s) 712 to perform processes described herein. Alternatively, hardwired circuitry may be used in place of or in combination with software instructions to implement processes described herein. Thus, implementations described herein are not limited to any specific combination of hardware circuitry and software.

Hardware portion **720** may include circuitry for efficiently processing traffic (such as packetized traffic) received by network BHR **440**. Hardware portion **720** may include, for example, logic, such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), and/or a ternary content-addressable memory (TCAM). Hardware portion **720** may, for example, receive incoming packets, extract header information for the packets, and process the packets based on the extracted header information.

Hardware portion **720** may particularly include a forwarding table **722**, a switch fabric **724**, and one or more buffers **726**. Forwarding table **722** may be determined based on routing tables maintained by software portion **710**. Forwarding table **722** may be used to lookup the appropriate output port for incoming packets. Forwarding table **722** may be updated based on the network protocols implemented by software portion **710**. Based on the result of the lookup in forwarding table **722**, packets may be switched to appropriate output ports through switch fabric **724**.

Buffer **726** may provide a buffer for queuing incoming packets. If packets arrive simultaneously, one or more of the packets may wait in the buffer until higher priority packets are processed and/or transmitted. Furthermore, because some interfaces may process traffic faster than others, buffer **726** may queue incoming packets that are received via a higher-speed interface (e.g., a MoCA interface on LAN side **530**) for forwarding on a slower-speed interface (e.g., an air interface on WAN side **510**). In one particular implementation, buffer **726** may buffer incoming packets received from customer premises network **110** (e.g., via the MoCA interface) until LTE module **420** can process them to be transmitted to LTE network **130** (e.g., via the air interface).

BHR **440** may also include ports for receiving and transmitting packets. A number of input ports **730** and output ports **740** are particularly shown for BHR **440**. Packets received at one of input ports **730** may, based on the application of forwarding table **722** and switch fabric **724**, be output at an appropriate one or more of output ports **740**.

Although BHR **440** is shown as including a software portion **710** and a hardware portion **720**, BHR **440** may, in some implementations, be implemented entirely through hardware. In some implementations, BHR **440** may include fewer, different, differently arranged, or additional components than depicted in FIG. 7. Alternatively, or additionally, one or more components of BHR **440** may perform one or more tasks described as being performed by one or more other components of BHR **440**.

As previously mentioned, BHR **440** may maintain a routing table. The routing tables may, for example, be maintained by software portion **710** and used to create forwarding table **722**.

FIG. 8 is a diagram illustrating an example portion of a routing table **800**, such as a routing table maintained by BHR **440**. Each row of routing table **800** may include a number of fields. Four fields are shown in example routing table **800**: a LAN destination IP address field **810**, a LAN port field **820**, a WAN destination IP address field **830**, and a WAN port field **840**.

LAN destination IP address field **810** may include an address or identifier for the destination of an incoming packet. The destination may be specified as, for example, an IPv4 (Internet Protocol, version 4) or IPv6 (Internet Protocol, version 6) address. IP addresses in LAN destination IP address field **810** may remain associated with a particular component/device. LAN port field **820** may include field for a physical or logical port associated with an IP addresses in LAN destination IP address field **810**.

WAN destination IP address field **830** may include an address or identifier for the destination of an incoming packet. The destination may be specified as, for example, an IPv4 or IPv6 address. IP addresses in WAN destination IP address field **830** may be assigned, for example, by LTE network **130** during initiation of a session. Thus, IP addresses in WAN destination IP address field **830** may change (e.g., for different sessions) over time. WAN port field **840** may include field for a physical or logical port associated with an IP addresses in WAN destination IP address field **830**.

Although FIG. 8 shows example fields of routing table portion **800**, in other implementations, routing table portion **800** may include fewer fields, different fields, or additional fields than depicted in FIG. 8.

FIG. 9 is a diagram of example components of a device **900** that may correspond to one of the devices of system **100** and/or customer premises network **110** (e.g., SIM **410**, LTE module **420**, BHR **440**, coaxial network controller **450**, local router **260**, etc.). As shown, device **900** may include a bus **910**, a processor **920**, a memory **930**, an input device **940**, an output device **950**, and a communication interface **960**.

Bus **910** may permit communication among the components of device **900**. Processor **920** may include one or more processors and/or microprocessors that interpret and execute instructions. Additionally or alternatively, processor **920** may be implemented as or include one or more ASICs, FPGAs, or the like. Memory **930** may include a RAM or another type of dynamic storage device that stores information and instructions for execution by processor **920**, a ROM or another type of static storage device that stores static information and instructions for the processor **920**, and/or some other type of magnetic or optical recording medium and its corresponding drive for storing information and/or instructions.

Input device **940** may include a device that permits an operator to input information to device **900**, such as a keyboard, a keypad, a mouse, a pen, a microphone, a touch screen, one or more biometric mechanisms, and the like. Output device **950** may include a device that outputs information to the operator, such as a display, a speaker, etc.

Communication interface **960** may include any transceiver-like mechanism that allows device **900** to communicate with other devices and/or systems. For example, communication interface **960** may include mechanisms for communicating with other devices, such as devices of FIG. 1 or FIG. 2.

Device **900** may perform certain functions in response to processor **920** executing software instructions contained in a computer-readable medium, such as memory **930**. The software instructions may be read into memory **930** from another computer-readable medium or from another device via communication interface **960**. The software instructions contained in memory **930** may cause processor **920** to perform processes that will be described later. Alternatively, hardwired circuitry may be used in place of or in combination with software instructions to implement processes consistent with embodiments described herein. Thus, systems and methods described herein are not limited to any specific combination of hardware circuitry and software.

Although FIG. 9 illustrates example components of device **900**, in some implementations, device **900** may include fewer components, different components, differently arranged components, or additional components than those depicted in FIG. 9. Additionally, or alternatively, one or more components of device **900** may perform one or more tasks described as being performed by one or more other components of device **900**.

FIG. 10 is a flow diagram illustrating a process 1000 for routing traffic between a WAN air interface and a LAN interface according to an implementation described herein. In one implementation, process 1000 may be performed by outdoor broadband unit 200. In other implementations, some or all of process 1000 may be performed by another device or a group of devices separate from and/or possibly remote from outdoor broadband unit 200 and/or including outdoor broadband unit 200.

Process 1000 may include receiving an IP data packet originating from a device within a LAN (block 1010), and sending, by a forwarding plane, the IP data packet toward a destination via an air interface for a WAN (block 1020). For example, outdoor broadband unit 200 (e.g., forwarding plane module 620 of LTE module 420) may receive and process user data, such as broadband traffic, from devices (e.g., devices 270) in customer premises network 110 for distribution to LTE network 130. Forwarding plane module 620 may receive data from customer premises network 110 via PCI interface 640 and may forward the data toward eNodeB 140 via radio interface 630.

Process 1000 may also include receiving an IP control packet originating from the device within the LAN (block 1030), and implementing, within a control plane, the IP control packet to initiate a test function for the network device (block 1040). For example, outdoor broadband unit 200 (e.g., control plane module 610 of LTE module 420) may perform control operations relating to testing and/or maintenance of LTE module 420 and/or connectivity to LTE network 130. In one implementation, control plane module 610 may receive a command to specify a test mode for testing LTE module 420. Control plane module 610 may receive IP control packets (e.g., to implement test functions) from devices 270 within customer premises network 110 via a MoCA interface. Thus, test functions of control plane module 610 may be accessed and/or implemented without using a separate physical connection to outdoor broadband unit 200.

Process 1000 may additionally include receiving, via the air interface for the WAN, another IP data packet (block 1050), and sending, by the forwarding plane, the other IP data packet toward the device within the LAN (block 1060). For example, outdoor broadband unit 200 (e.g., forwarding plane module 620 of LTE module 420) may receive and process user data, such as broadband traffic, for distribution to devices (e.g., user devices 270) in customer premises network 110. For example, forwarding plane module 620 may receive data from LTE network 130 via radio interface 630 and may forward the data toward user devices 270 in customer premises network 110 via PCI interface 640.

Systems and/or methods described herein may include an outdoor broadband unit that implements full IP-based routing between a WAN-side interface (e.g., for LTE) and a LAN-side interface (e.g., using MoCA protocol). The outdoor broadband unit may maintain a routing table for all connections through an internal routing system based on matching between WAN-side IP addresses and/or ports and LAN-side IP addresses and/or ports. The systems and/or methods may support both connection-oriented and connectionless transport layer routing.

The foregoing description of implementations, described above, provides illustration and description, but is not intended to be exhaustive or to limit the invention to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention.

For example, while a series of blocks has been described with regard to FIG. 10, the order of the blocks may be modified in other implementations. Further, non-dependent blocks may be performed in parallel.

Also, certain portions of the implementations may have been described as a “component” or “module” that performs one or more functions. The terms “component” and “module” may include hardware, such as a processor, an ASIC, or a FPGA, or a combination of hardware and software (e.g., software running on a processor).

It will be apparent that aspects described herein may be implemented in many different forms of software, firmware, and hardware in the implementations illustrated in the figures. The actual software code or specialized control hardware used to implement aspects does not limit the embodiments. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware can be designed to implement the aspects based on the description herein.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of the invention. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one other claim, the disclosure of the invention includes each dependent claim in combination with every other claim in the claim set.

No element, act, or instruction used in the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article “a” is intended to include one or more items. Where only one item is intended, the term “one” or similar language is used. Further, the phrase “based on” is intended to mean “based, at least in part, on” unless explicitly stated otherwise.

What is claimed is:

1. A system comprising:

- a satellite antenna to receive communications from a satellite network; and
- an outdoor broadband unit connected to an external portion of a customer premises along with the satellite antenna, the outdoor broadband unit including:
 - a radio frequency (RF) antenna to receive communications from a Long-Term Evolution (LTE) network,
 - a LTE module to implement an air interface for the LTE network, the LTE module including a control plane module to perform control operations relating to testing of the LTE module and a forwarding plane module to transfer user data,
 - a coaxial network controller to provide an interface to a local area network (LAN), associated with the customer premises, for Ethernet over coaxial signals,
 - a broadband home router to route traffic, from the LAN, to both the control plane module and the forwarding plane module of the LTE module, wherein the broadband home router includes a memory to buffer Ethernet traffic between the coaxial network controller and the LTE module, and
 - a radome to contain the RF antenna, the LTE module, the coaxial network controller, and the broadband home router.

2. The system of claim 1, where the LTE module, the coaxial network controller, and the broadband home router are included on a single printed wiring board.

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3. The system of claim 1, where the broadband home router implements Internet Protocol (IP) routing between the LTE module and the coaxial network controller.

4. The system of claim 1, where the broadband home router is coupled to the LTE module via a peripheral component interconnect (PCI) interface. 5

5. The system of claim 1, where the broadband home router maintains a routing table for all connections through the broadband home router based on matching between IP addresses on the LTE network and IP addresses in the LAN network. 10

6. The system of claim 1, where the broadband home router supports both connection-oriented and connectionless transport layer routing.

7. The system of claim 1, where the control plane module of the LTE module receives command signals, from the LAN, to implement test or maintenance procedures for the LTE module. 15

8. A device, comprising:

a radio frequency (RF) antenna to receive communications from a Long-Term Evolution (LTE) network; 20
a printed wiring board including:

an antenna port to connect to the RF antenna, a LTE module to implement an air interface for the LTE network, the LTE module including a control plane module to perform control operations relating to testing of the LTE module and a forwarding plane module to transfer user data, 25

a coaxial network controller to provide an interface to a local area network (LAN) for Ethernet over coaxial signals, and 30

a broadband home router to route traffic, from the LAN, to the control plane module and the forwarding plane module of the LTE module, wherein the broadband home router includes a memory to buffer Ethernet traffic between the coaxial network controller and the LTE module, and 35

a radome to contain the RF antenna and the printed wiring board.

9. The device of claim 8, where the broadband home router implements Internet Protocol (IP) routing between the LTE module and the coaxial network controller. 40

10. The device of claim 8, where the control plane module of the LTE module receives command signals, from the LAN, to implement test or maintenance procedures for the LTE module. 45

11. The device of claim 8, where the broadband home router maintains a routing table for all connections through the broadband home router based on matching between IP addresses on the LTE network and IP addresses in the LAN network. 50

12. A system comprising:

a satellite antenna to receive communications from a satellite network; and

an outdoor broadband unit connected to an external portion of a customer premises along with the satellite antenna, the outdoor broadband unit including: 55

a radio frequency (RF) antenna to receive communications from a Long-Term Evolution (LTE) network,

a LTE module to implement an air interface for the LTE network, the LTE module including a control plane module to perform control operations relating to testing of the LTE module and a forwarding plane module to transfer user data, and wherein the control plane 60

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module receives command signals, from the LAN, to implement test or maintenance procedures for the LTE module,

a coaxial network controller to provide an interface to a local area network (LAN), associated with the customer premises, for Ethernet over coaxial signals,

a broadband home router to route traffic, from the LAN, to both the control plane module and the forwarding plane module of the LTE module, and

a radome to contain the RF antenna, the LTE module, the coaxial network controller, and the broadband home router.

13. The system of claim 12, wherein the LTE module, the coaxial network controller, and the broadband home router are included on a single printed wiring board.

14. The system of claim 12, wherein the broadband home router implements Internet Protocol (IP) routing between the LTE module and the coaxial network controller.

15. The system of claim 12, wherein the broadband home router is coupled to the LTE module via a peripheral component interconnect (PCI) interface.

16. The system of claim 12, wherein the broadband home router includes a memory to buffer Ethernet traffic between the coaxial network controller and the LTE module.

17. The system of claim 12, where the broadband home router maintains a routing table for all connections through the broadband home router based on matching between IP addresses on the LTE network and IP addresses in the LAN.

18. The system of claim 12, where the broadband home router supports both connection-oriented and connectionless transport layer routing.

19. A device, comprising:

a radio frequency (RF) antenna to receive communications from a Long-Term Evolution (LTE) network;

a printed wiring board including:

an antenna port to connect to the RF antenna, a LTE module to implement an air interface for the LTE network, the LTE module including a control plane module to perform control operations relating to testing of the LTE module and a forwarding plane module to transfer user data, wherein the control plane module receives command signals, from the LAN, to implement test or maintenance procedures for the LTE module, 65

a coaxial network controller to provide an interface to a local area network (LAN) for Ethernet over coaxial signals, and

a broadband home router to route traffic, from the LAN, to the control plane module and the forwarding plane module of the LTE module, and

a radome to contain the RF antenna and the printed wiring board.

20. The device of claim 19, where the broadband home router implements Internet Protocol (IP) routing between the LTE module and the coaxial network controller.

21. The device of claim 19, wherein the broadband home router includes a memory to buffer Ethernet traffic between the coaxial network controller and the LTE module.

22. The device of claim 19, where the broadband home router maintains a routing table for all connections through the broadband home router based on matching between IP addresses on the LTE network and IP addresses in the LAN.

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